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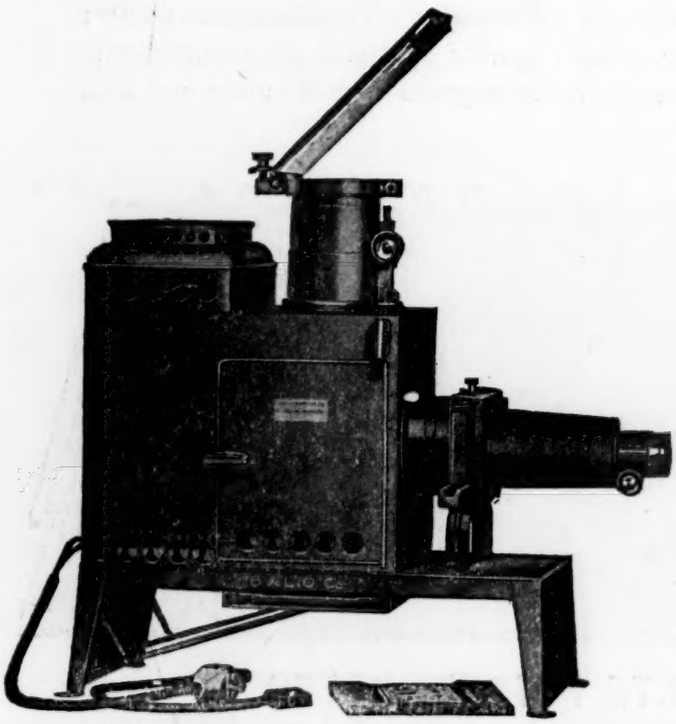

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FRIDAY, JANUARY 16, 1920

CONTENTS

The American Association for the Advancement of Science:—
Recent Advances in Dynamics: PROFESSOR GEORGE D. BIRKHOFF 51

Sir William Osler: LIEUTENANT COLONEL F. H. GARRISON 55

Scientific Events:—
A Botanic School in Regent's Park; The Attitude of German Physicians towards Inhuman Actions; Conference on Waste of Natural Gas; Scientific Lectures 58

Scientific Notes and News 60

University and Educational News 62

Discussion and Correspondence:—
Musical Sands: PROFESSOR H. L. FAIRCHILD. *More on Singing Sands:* E. O. FIPPIN. *The Initial Course in Biology:* PROFESSOR YANDELL HENDERSON 62

Scientific Books:—
Chumley on the Fauna of the Clyde Sea Area: PROFESSOR CHARLES A. KOFOID..... 65

The Ecological Society and its Opportunity: DR. BARRINGTON MOORE 66

The Canadian Branch of the American Phytological Association 68

The American Chemical Society: DR. CHARLES L. PARSONS 69

MSS. intended for publication and books, etc., intended for review should be sent to The Editor of Science, Garrison-on-Hudson, N. Y.

RECENT ADVANCES IN DYNAMICS[1]

A HIGHLY important chapter in theoretical dynamics began to unfold with the appearance in 1878 of G. W. Hill's researches in the lunar theory.

To understand the new direction taken since that date it is necessary to recall the main previous developments. In doing this, and throughout, we shall refer freely for illustration to the problem of three bodies.

The concept of a dynamical system did not exist prior to Newton's time. By use of his law of gravitation Newton was able to deal with the Earth, Sun, and Moon as essentially three mutually attracting particles, and by the aid of his fluxional calculus he was in a position to formulate their law of motion by means of differential equations. Here the independent variable is the time and the dependent variables are the nine coordinates of the three bodies. Such a set of ordinary differential equations form the characteristic mathematical embodiment of a dynamical system, and can be constructed without especial difficulty.

The aim of Newton and his successors was to find explicit expressions for the coordinates in terms of the time for various dynamical systems, just as Newton was able to do in the problem of two bodies. Despite notable successes, the differential equations of the problem of three bodies and of other analogous problems continued to defy "integration."

Notwithstanding the lack of explicit expressions for the coordinates, Newton was able to treat the lunar theory from a geometrical point of view. Euler, Laplace, and others invented more precise analytical methods based upon series. In both cases the bodies which are disturbing the motion of the

[1] Address of the vice-president and chairman of Section A—Mathematics and Astronomy—American Association for the Advancement of Science, St. Louis, December, 1919.

Moon are assumed first to move in certain periodic orbits, and the perturbations of the Moon are assumed to be the same as if the other bodies did move in such hypothetical orbits. The principle of successive approximations characterizes these methods.

The chief other advance made was based on the following principle: if a function is a maximum or minimum when expressed in terms of one set of variables it is also a maximum or minimum for any other set; hence, if the differential equations of dynamics can be looked upon as the equations for a maximum or minimum problem, this property will persist whatever variables be employed. This principle, developed mainly by Lagrange, W. R. Hamilton, and Jacobi, enables one to make the successive changes of variables required in the method of successive approximations by merely doing so in a single function.

Here too the results are chiefly of formal and computational importance.

The last great figure of this period is Jacobi. His "Vorlesungen über Dynamik" published in 1866 represents a highwater mark of achievement in this direction.

Nearly all fields of mathematics progress from a purely formal preliminary phase to a second phase in which rigorous and qualitative methods dominate. From this more advanced point of view, inaugurated in the domain of functions of a complex variable by Riemann, we may formulate the aim of dynamics as follows: to characterize completely the totality of motions of dynamical systems by their qualitative properties.

In Poincaré's celebrated paper on the problem of three bodies, published in 1889, where he develops much that is latent in Hill's work, Poincaré proceeds to a treatment of the subject from essentially this qualitative point of view.

A first notion demanding reconsideration was that of integrability, which had played so great a part in earlier work. In 1887 Bruns had proved that there were no further algebraic integrals in the problem of three bodies. Poincaré showed that in the so-called restricted problem there were no further integrals existing for all values of a certain parameter and in the vicinity of a particular periodic orbit. Later (1906) Levi-Civita has pointed out that there are further integrals of a similar type in the vicinity of part of any orbit.

Thus it has become clear that the question as to whether a given dynamical problem is integrable or not depends on the kind of definition adopted. However, the most natural definitions have reference to the vicinity of a particular periodic motion. The introduction of a parameter by Poincaré is to be regarded as irrelevant to the essence of the matter.

From the standpoint of pure mathematics, a just estimate of the results found in integrable problems may be obtained by reference to the problem of two bodies, or, more simply still, of the spherical pendulum. The integration by means of elliptic functions shows that the pendulum bob rotates about the vertical axis of the sphere through a certain angle in swinging between successive highest and lowest points. But the form of the differential equation renders this principal qualitative result self-evident, while the most elementary existence theorems for differential equations assure one of the possibility of explicit computation. Hence the essential importance of carrying out the explicit integration lies in its advantages for purposes of computation.

The series used in the calculations of the lunar theory and other similar theories were given their proper setting by Poincaré. He showed that they were in general divergent, but were suitable for calculation because they represented the dynamical coordinates in an asymptotic sense.

The fact that the first order perturbations of the axes in the lunar theory can be formally represented by such trigonometric series had led astronomers to believe that the perturbations remained small for all time. But the fact of divergence made the argument for stability inconclusive.

It is easy to see that this question of stability, largely unsolved even to-day, is of fundamental importance from the point of

view formulated above. For, in a broad sense, the question is that of determining the general character of the limitations upon the possible variations of the coordinates in dynamical problems.

We wish to mention briefly four important steps in advance in this direction.

The first is due to Hill who showed in his paper that, in the restricted problem of three bodies, with constants so chosen as to give the best approximation for the lunar theory, the Moon remains within a certain region about the Earth, not extending to the Sun. In fact here there is an integral yielding the squared relative velocity as a function of position, and the velocity is imaginary outside of this region.

In his turn, Poincaré showed that stability exists in another sense, namely for arbitrary values of the coordinates and velocities there exist nearby possible orbits of the Moon which take on infinitely often approximately the same set of values. His reasoning is extremely simple, and is founded on a hydrodynamic interpretation in which the orbits appear as the stream lines of a three-dimensional incompressible fluid of finite volume in steady motion. A moving molecule of such a fluid must indefinitely often partially reoccupy its original position with indefinite lapse of time, and this fact yields the stated conclusion.

In 1901 under the same conditions Levi-Civita proved that, if the mean motions of the Sun and Moon about the Earth are commensurable, instability exists in the following sense: orbits as near as desired to the fundamental periodic lunar orbit will vary from that periodic orbit by an assignable amount after sufficient lapse of time. This result, which is to be anticipated from the physical point of view, makes it highly probable that instability exists in the incommensurable case also.

These three results refer to the restricted problem of three bodies.

Finally there is Sundman's remarkable work on the unrestricted problem contained in his papers of 1912 and of earlier date. Lagrange had proved that if a certain energy constant is negative, the sum of the mutual distances of the three bodies becomes infinite. Sundman showed that, even if this constant is positive, the sum of the three mutual distances always exceeds a definite positive quantity, at least if the motion is not essentially in a single plane. Thus he incidentally verified a conjecture of Weierstrass that the three bodies can never collide simultaneously. These and other results seem to me to render it probable that *in general* the sum of the three distances increases indefinitely. Thus, if this conjecture holds, in that approximation where the Earth, Sun and Moon are taken as three particles, the Earth and Moon remain near each other but recede from the Sun indefinitely. The situation is worthy of the attention of those interested in astronomy and in atomic physics.

As we have formulated the concept of stability, it is essentially that of a permanent inequality restricting the coordinates. We may call a dynamical system transitive in a domain under consideration if motions can be found arbitrarily near any one state of motion of the domain at a particular time which pass later arbitrarily near any other given state. In such a domain there is instability. If we employ the hydrodynamic interpretation used above, the molecule of fluid will diffuse throughout the corresponding volume in the transitive case, and will diffuse only partially or not at all in the intransitive case. The geodesics on surfaces of negative curvature, treated by Hadamard in 1898, furnish a simple illustration of a transitive system, while the integrable problem of two bodies yields an intransitive system. Probably only under very special conditions does intransitivity arise.

It is an outstanding problem of dynamics to determine the character of the domains within which a given dynamical system is transitive.

A less difficult subject than that of stability is presented by the singularities of the motions such as arise in the problem of three bodies at collision. The work of Levi-Civita and Sundman especially has shown that the singularities can frequently be eliminated by

means of appropriate changes of variables. In consequence the coordinates of dynamical systems admit of simple analytic representation for all values of the time. In particular Sundman has proved that the coordinates and the time in the problem of three bodies can be expressed in terms of permanently convergent power series, and thus he has "solved" the problem of three bodies in the highly artificial sense proposed by Painlevé in 1897. Unfortunately these series are valueless either as a means of obtaining qualitative information or as a basis for numerical computation, and thus are not of particular importance.

From early times the mind of man has persistently endeavored to characterize the properties of the motions of the stars by means of periodicities. It seems doubtful whether any other mode of satisfactory description is possible. The intuitive basis for this is easily stated: any motion of a dynamical system must tend with lapse of time towards a characteristic cyclic mode of behavior.

Thus, in characterizing the motions of a dynamical system, those of periodic type are of central importance and simplicity. Much recent work has dealt with the existence of periodic motions, mainly for dynamical systems with two degrees of freedom.

An early method of attack was that of analytical continuation, due to Hill and Poincaré. A periodic motion maintains its identity under continuous variation of a parameter in the dynamical problem, and may be followed through the resultant changes. G. Darwin, F. R. Moulton and others have applied this method to the restricted problem of three bodies. Symmetrical motions can be treated frequently by particularly simple methods. Hill made use of this fact in his work.

Another method is based on the geodesic interpretation of dynamical problems. This has been developed by Hadamard, Poincaré, Whittaker, myself, and others. The closed geodesics correspond to the periodic motions, and the fact that certain closed geodesics of minimum length must exist forms the basis of the argument in many cases. As an example of another type, take any surface with the connectivity of a sphere and imagine to lie in it a string of the minimum length which can be slipped over the surface. Clearly in being slipped over the surface there will be an intermediate position in which the string will be taut and will coincide with a closed geodesic.

Finally there is a less immediate method of attack which Poincaré introduced in 1912, and which I have tried to extend. By it the existence of periodic motions is made to depend on the existence of invariant points of certain continua under one-to-one continuous transformation. The successful application of this method involves a preliminary knowledge of certain of the simpler periodic motions.

Periodic motions fall into two classes which we may call hyperbolic and elliptic. In the hyperbolic case analytic families of nearby motions asymptotic to the given periodic motion in either sense exist, while all other nearby motions approach and then recede from it with the passing of time. In the elliptic case the motion is formally stable, but the phenomenon of asymptotic families not of analytic type arises unless the motion is stable in the sense of Levi-Civita.

In a very deep sense the periodic motions bear the same kind of relation to the totality of motions that repeating doubly infinite sequences of integers 1 to 9 such as

. . . 2323 . . .

do to the totality of such sequences.

In trying to deal with the totality of possible types motion it seems desirable to generalize the concept of periodic motion to recurrent motion as follows: any motion is recurrent if, during any interval of time in the past or future of sufficiently long duration T, it comes arbitrarily near to all of its states of motion. With this definition I have proved that every motion is either recurrent or approaches with uniform frequency arbitrarily near a set of recurrent motions.

The recurrent motions correspond to those double sequences specified above in which every finite sequence which is present at all occurs

at least once in every set of N successive integers of the sequence.

In any domain of transitivity the two extreme types of motion are the recurrent motions on the one hand and the motions which pass arbitrarily near every state of motion in the domain on the other. Both types necessarily exist, as well as other intermediate types.

The precise nature of such recurrent motions has yet to be determined, but Dr. H. C. M. Morse in his 1918 dissertation at Harvard has shown that there exists non-periodic recurrent motions of entirely new type in simple dynamical problems.

Such are a few of the steps in advance that theoretical dynamics has taken in recent years. I wish in conclusion to illustrate by a very simple example the type of powerful and general geometric method of attack first used by Poincaré.

Consider a particle P of given mass in rectilinear motion through a medium and in a field of force such that the force acting upon P is a function of its displacement and velocity. In order to achieve simplicity I will assume further that the law of force is of such a nature that, whatever be the initial conditions, the particle P will pass through a fixed point O infinitely often.

If P passes O with velocity v it passes O at a first later time with a velocity v_1 of opposite sign. We have then a continuous one-to-one functional relation $v_1 = f(v)$. If v is taken as a one-dimensional coordinate in a line, then the effect of the transformation $v_1 = f(v)$ is a species of qualitative "reflection" of the line about the point O.

If this "reflection" is repeated the resultant operation gives the velocity of P at the second passage of O, and so on. But the most elementary considerations show that either (1) the reflection thus repeated brings each point to its initial position, or (2) the line is broken up into an infinite set of pairs of intervals, one on each side of O, which are reflected into themselves, or (3) there is a finite set of such pairs of intervals, or (4) every point tends toward O (or away from it) under the double reflection.

Hence there are four corresponding types of systems that may arise. Either (1) every motion is periodic and O is a position of equilibrium, or (2) there is an infinite discrete set of periodic motions of increasing velocity and amplitude (counting the equilibrium position at O as the first) such that, in any other motion, P tends toward one of these periodic motions as time increases and toward an adjacent periodic motion in past time, or (3) there is a finite set of periodic motions of similar type such that, in any other motion, P behaves as just stated, if there be added a last periodic motion with "infinite velocity and amplitude" as a matter of convention, or (4) in every motion P oscillates with diminishing velocity and amplitude about O as time changes in one sense and with ever increasing velocity and amplitude as time changes in the opposite sense.

Here we have used the obvious fact that there is a one-to-one correspondence between velocity at O and maximum amplitude in the immediately following quarter swing.

This example illustrates the central rôle of periodic motions in dynamical problems. It is also easy to see in this particular example that the totality of motions has been completely characterized by these qualitative properties in a certain sense which we shall not attempt to elaborate.

What is the place of the developments reviewed above in theoretical dynamics?

The recent advances supplement in an important way the more physical, formal, and computational aspects of the science by providing a rigorous and qualitative background.

To deny a position of great importance to these results, because of a lack of emphasis upon the older aspects of the science would be as illogical as to deny the importance of the concept of the continuous number system merely because of the fact that in computation attention is confined to rational numbers.

GEORGE D. BIRKHOFF

SIR WILLIAM OSLER (1849–1919)

AFTER a tedious and painful illness, Sir William Osler, Regius professor of medicine at Oxford, died at his home in Norham Gardens on December 9, 1919. In spite of in-

termediate convalescence, a severe attack of bronchitis, due to exposure through attending a professional consultation, developed into a pneumonia with pleurisy and empyema, necessitating surgical drainage; and although he had been cheerful three days before his death, the end was gravely apprehended by those around him. He is survived by his widow, Lady Osler, and two brothers, his only son having been killed in the war.

Sir William Osler, the son of Rev. F. L. Osler of Falmouth, England, was born at Bond Head, Province of Ontario, Canada, on July 12, 1849. A medical graduate of McGill University (1872) with the customary post graduate study in the London clinics and German universities, he became lecturer and professor of the institutes of medicine at McGill in 1874 and easily rose, without stress or undue effort, to the top of his profession. In succession, he was professor of medicine at the University of Pennsylvania (1884–9) and the Johns Hopkins University (1889–1904), was appointed Regius professor of medicine at the University of Oxford in 1904 and received his baronetcy in 1911. On July 11, 1919, his seventieth birthday was honored by the presentation of two anniversary volumes made up of contributions by English and American colleagues.[1] Due to delays in printing, the completed volumes reached him only a few days before his death.

Of Osler's scientific work, it may be said that no great physician has been more firmly grounded in the fundamental disciplines of his calling. Of the arduous years of post-mortem work at Montreal the Pathological Reports of the Montreal General Hospital (1876–80) are a permanent record, as also the eight editions of the great text-book on Practice of Medicine (1892), which has been translated into French, German, Spanish and Chinese. The disciple of Morgagni and Virchow is equally apparent in the hundreds of clinical papers, the larger monographs in Osler's "Modern Medicine" (1907–10), the Gullstonian lectures on malignant endocarditis (1885), and the separate treatises on the cerebral palsies of children (1889), chorea (1894), abdominal tumors (1895), angina pectoris (1897), and cancer of the stomach (1900). From the start he did much original investigation of high quality. At the age of twenty-five (1874), he described the blood platelets associated with the name of Bizzozero, and defined their status as the third corpuscle of the blood and their relation to the formation of thrombi. Such early papers as those on the blood in pernicious anemia (1877), overstrain of the heart (1878), fusion of the semi-lunar valves (1880) reveal the born clinical and pathological observer. Osler was a profound student of all modes of aneurism, of tuberculosis, of typhoid fever, of disorders of the circulation. He was the first to emphasize the relation between mycotic aneurism and mycotic endocarditis, first described the ball-valve thrombus at the mitral orifice, the visceral complication of erythema multiforme (1895), chronic cyanosis with polycythemia, known as Vaquez' disease (1895), multiple telangiectasis (1901), the erythematous spots in malignant endocarditis (1908), and he discovered the parasite of verminous bronchitis in dogs (*filaria Osleri*, 1877). But to sense the magnitude of Osler's clinical work, it must be taken by and large in the 730 titles of the recently published Osler Bibliography (1919).

At the farewell banquet given him in New York in 1904, Osler said that he desired to be remembered in a single line: "He taught clinical medicine in the wards." He found his great opportunity when he became physician to the Johns Hopkins Hospital. During the six years intervening between the opening of the hospital (1889) and the beginning of undergraduate instruction in medicine (1893), Osler blocked out the arrangements for a graded whole-time upper resident staff of men of exceptional promise, a lower resident staff of one year internes, careful instruction in case-taking and clinical laboratory work for third year students and the appointment of fourth year students as "clinical clerks," in actual charge of patients in hospital, for three months each. The feeling of confidence and of personal responsibility acquired by these advantages was further strengthened by assigning advanced pupils to

[1] Science, September 12, 1919, p. 244.

teach extempore, to read and report on foreign literature, to cultivate the history of their profession. In his Saturday night meetings at his home in West Franklin Street, his aim with young students was to make good physicians of them, to make good men out of them, to teach them to think for themselves and to be themselves. As Dr. H. M. Thomas has said, Osler "put the students in the wards, but he did not leave them there; he stayed with them"; and he adds: "What good there is in me as a teacher and a physician I owe to him." This is the common sentiment, that he took his students with him into the upper reaches of their profession and the broad sunshine of actual life. Only Astley Cooper or Carl Ludwig could have produced such a train of loyal disciples; only Pasteur could have inspired such universal regard and affection.

Space permits but a passing reference to Osler's work on the history of medicine, to which, through his personal interest and his many unique contributions, he gave a greater impetus than any other; to his civic activities, his labors in behalf of medical libraries, his splendid service to his country in wartime. His great collection of original texts and documents relating to discoveries and advances in the science and art of medicine, the hobby of his later years, was all but completed as to items, but the big human touch which would have made its catalogue one of the unique things in medical bibliography could only have been given by Osler himself.

Essentially English in character, Osler had, through his forebears, Cornish and Spanish elements in his composition, easily sensed in the "hauntings of Celtism" in his ringing eloquent voice, the suggestion of the hidalgo in his slender, aristocratic figure, the clean-cut features and the tropical brown eyes. His was the longish head of the man of action, the active practitioner against disease and pain. Osler's warm glance and utter friendliness of manner told how naturally fond he was of people. He had the gift of making almost any one feel for the moment as if he were set apart as a valued particular friend, and so became, in effect, a kind of universal friend to patients, pupils and colleagues alike. But there was nothing of the politician in him. He rather paid with his person through the demands made by importunate patients and visitors upon his time. Such an effective concentration of the "fluid, attaching character" has seldom been found in a single personality, possessed, as it were, by the impartial, non-exclusive spirit of all pervading Nature, "which never was the friend of one,"

> But lit for all its generous sun,
> And lived itself, and made us live.

Many are the tales of the clever hoaxing and practical joking put over by Osler on his boon companions and professional fellows in his salad days, but the chaffing was carried on in such a jolly spirit that it left no sting behind. In his address on the male climacteric, delivered on the occasion of his retirement from the Johns Hopkins faculty, he found to his dismay that he had chaffed a whole nation. The hazards incurred by his chance reference to Trollope's fable about "chloroforming at sixty" have been set forth at undue length in the public press and even on the stage. But Osler's reasoning about the comparative uselessness of men at sixty, in the face of the imposing array of exceptions in Longfellow's "Morituri Salutamus," was obviously an expression of his essential preference for and innate sympathy with the oncoming race of younger people, whose worth he had sensed many times over in his beloved pupils.

The last two years of Sir William Osler's life were clouded by the death of his only son, Lieutenant Revere Osler, an artillery officer and a youth of great promise, who was killed in the action about Ypres in 1917. This he bore bravely, concealing his grief from his friends and busying himself with his own duties to the sick and wounded, but, the war at an end, his loneliness increased in spite of the companionship of his wife and his ever-generous hospitality to American officers and physicians. Toward the end, his intimates began to realize that he had "trod the upward and the downward slope" and was done with life. Up to that time he had remained cheer-

ful, buoyant, resilient, as if, like the beloved of the gods, he was predestined to die young. Yet the supreme test was nobly borne, and to many of his pupils and colleagues, who see in the death of this great, benignant physician, the loss of their best friend, the expressions of ancient belief will not seem unavailing: *Requiem æternam dona ei, Domine, et lux perpetua luceat ei.*

F. H. Garrison

Army Medical Museum

SCIENTIFIC EVENTS

A BOTANIC SCHOOL IN REGENT'S PARK

The report of the committee appointed last April by Lord Ernle, the former president of the British Board of Agriculture, to consider what steps should be taken to improve the usefulness of the Royal Botanic Society in London, is now published and an abstract is given in the London *Times*. The members of the committee, all of whom sign the report, were: Lieutenant-Colonel Sir David Prain, F.R.S., director of the Royal Botanic Gardens, Kew (chairman); Sir W. H. Dunn; Surgeon-General Sir A. Keogh, Imperial College of Science and Technology; Sir Malcolm Morris; Major R. C. Carr;Mr. Morton Evans, joint secretary of the Office of Woods; Mr. H. J. Greenwood, L.C.C.; and Professor F. W. Keeble, F.R.S., Board of Agriculture and Fisheries and Royal Horticultural Society; with Mr. G. C. Gough, B.Sc., secretary.

The society was incorporated in 1839, and was granted a lease of 18 acres in Regent's Park until 1870. This lease was renewed by the Commissioners of Woods and Forests in 1870, and in 1901 at an increased rental. The present lease terminates in 1932.

The committee have formed the opinion that the Royal Botanic Society could be made more useful both from the scientific and educational point of view by the establishment of: (1) A school of economic botany, at which a knowledge of the economic plants and their products including those of tropical regions, might be obtained; (2) an institute which might be made a center for research, more especially in plant physiology where the living plant is essential; (3) a center for teaching in horticulture, the students of which could receive their necessary training in pure science at existing London colleges; (4) courses in school gardening, at times suitable for teachers in elementary, continuation, and other schools. In addition, the committee consider that the gardens might extend their present utility as a center from which colleges and botany schools could be supplied with material for teaching and research, and in which students could make use of the existing facilities for the study of systematic botany.

In an appendix the committee deal with the financial side of the scheme. They consider that the suggestions need not entail, in their initial stages, any very great expenditure. Buildings should be of a temporary nature and of not more than two stories, and might be erected near the present greenhouses. After giving details of the laboratories and rooms required, the committee suggest that the staff should consist of the following:

A director at a salary of £800 to £1,000, able to cooperate with the teachers of botany in London, and with a knowledge of economic problems or of vegetable physiology. An assistant director, salary £500 to £700, to be appointed after the director. His knowledge should supplement that of the director—*e. g.*, if the former be an economic botanist the latter should be a physiological botanist. An assistant, salary £250 to £400, to act as curator of the museum and librarian, with a general knowledge of plant diseases. At least one of the officers should have a practical knowledge of the tropics, tropical plants, and their products.

The committee estimate the total cost of the staff, with attendants, etc., at £3,000 to £3,500 per annum; the cost of the buildings, £4,000; and the cost of equipment, including books, plants, etc., £500.

THE ATTITUDE OF GERMAN PHYSICIANS TOWARDS INHUMAN ACTION

It will be remembered that a protest signed by M. Calmette and four other members of scientific organizations who had remained at Lille during the occupation by the Germans,

charged acts of inhumanity, saying in conclusion: "The high command in Germany willed the war, but the people in arms approved it, and resolutely waged war with the most ferociously cruel means, even the physicians with the army doing the most odious acts without a word of excuse, regret or pity." The *Deutsche, medizinische Wochenschrift* of April 10, 1919, as quoted in the *Journal* of the American Medical Association, related that the matter was brought up in the Berlin Medical Society, and Calmette's protest and the resolutions voted thereon by the Académie de médecine at Paris were discussed. Dr. Fuld offered a resolution that the society should go on record as expressing its regret at such happenings as were specified in the Calmette protest, but his suggestion was opposed by Orth and others, the speakers saying that there was no proof of the truth of the statements made by Calmette, and no voting should be done on a matter of which only one side had been presented. Finally a committee was appointed to report after obtaining an official copy of the resolutions that had been adopted by the Académie. The *Wochenschrift* of November 6, 1919, relates that this committee recently presented its report. It was in the form of a resolution which was adopted without a dissenting voice. The members of the committee were Fuld, Kraus, Krause, Morgenroth and Schwalbe, the latter the editor of the *Wochenschrift*. The resolution in translation reads:

> The Berlin Medical Society is not in a position to pass judgment on the Manifesto of the Lille professors and the Académie de Médicine and on the published justification issued by the German authorities, entitled "Lille under German Rule and the Criticism of the Foe." But the society does not hesitate to declare openly that it condemns in the most unqualified manner all inhuman actions, wherever, whenever, and by whomsoever they may be committed. This attitude corresponds to the spirit of medicine always held high by the German medical profession, that really international spirit to which we are loyal and to which we assume all other physicians are loyal wherever they may be and to whatever nation they may belong.

CONFERENCE ON WASTE OF NATURAL GAS

A PUBLIC conference of governors, public utility commissioners, state geologists, home economic experts, natural gas companies, owners and officials, and appliance manufacturers has been called by Secretary of the Interior Lane to meet under the auspices of the Bureau of Mines at the Interior Department Building, Washington on January 15, to discuss the waste of natural gas in this country both by consumers and gas companies. As a result of the work of the experts of the bureau on this question, it is declared that in using natural gas the consumers through faulty appliances obtain an efficiency of about 13 per cent. from a gas cook stove, 25 per cent. from a house-heating furnace, and 10 per cent. from a hot-water heater, although in good practise these efficiencies can be trebled. Dr. Van H. Manning, director of the Bureau of Mines, writes in regard to the purposes of the conference:

> Domestic consumers waste more than 80 per cent. of the gas received. The efficiency of most cooking and heating appliances could be trebled. By making natural gas worth saving the 2,400,000 domestic consumers in the United States could get the same cooking and heating service with one third the gas; that is, make one foot of gas do the work of three and greatly delay the day when the present supplies will be exhausted and consumers must go back to more expensive manufactured gas.
>
> It is time for the public to take a new viewpoint on the waste of natural gas. It is time for the domestic consumer to realize that his duty is not done when he cries out against the flagrant wastes occurring in the gas fields and demands of his government that such wastes be abated; he must realize that he himself is likewise at fault and that it is time for him to set his own house in order. Furthermore, the domestic consumer must realize that these wastes do not concern him alone, and consequently he has not the right, merely because he pays for the gas, to employ it in any manner that pleases him, no matter how wasteful. Natural gas is a natural resource in which every inhabitant of this country has an equity. Those who waste the gas do so at the expense of those who would use it efficiently. Natural gas is not replaced by nature, and in comparison with the life

of the nation the duration of the supply will be brief.

The public has a right, therefore, to demand that this natural asset be used to the greatest advantage of all and that no one be allowed to waste it. Natural gas in each ctiy is a community asset and every consumer has a right to demand that wasteful use shall be prohibited in the interest of the public service. This is particularly important during cold spells in the winter when the supply is insufficient and actual suffering may occur. Clearly, it is not right that any consumer suffer at such times because of the extravagance and waste of other consumers, even though they are willing to pay for the gas wasted. Nor can the citizens justify demands for better service from the public utilities without making provision to correct abuses in their own homes. It must be recognized that the public has been and is to-day just as much a party to the crime of wasting this natural resource as are the companies that produce and market it.

SCIENTIFIC LECTURES

Under the auspices of the division of geology of Harvard University, Dr. James Mackintosh Bell, former government geologist of New Zealand, will give a series of nine lectures on topics in economic geology. These lectures are given in the Geological Lecture Room, Geological Museum, at 4.30 o'clock, and will be open to the public. The dates and titles are as follows:

January 5. "The Waihi goldfield, New Zealand."

January 7. "The Mount Morgan copper mine, Queensland."

January 9. "The Mount Bischoff tin mine, Tasmania."

January 12. "The Mount Lyell copper mine, Tasmania."

January 14. "The Spassky copper mines, Siberia."

January 16. "The Atbasar copper mines, Siberia."

January 19. "The Sadbury nickel-copper area, Ontario."

January 20. "The Cobalt Silver Camp, Ontario."

January 21. "The Porcupine goldfields, Ontario."

The following are among the lectures to be given at the Royal Institution: Professor W. H. Bragg, six lectures adapted to a juvenile auditory on The World of Sound; Sir John Cadman, two lectures on (1) Modern Development of the Miner's Safety Lamp and (2) Petroleum and the War; Professor G. Elliot Smith, three lectures on The Evolution of Man and the Early History of Civilization; Professor Ernest Wilson, two lectures on Magnetic Susceptibility; Professor Arthur Keith, four lectures on British Ethnology: The Invaders of England; Professor A. E. Conrady, two lectures on Recent Progress in Photography; Professor A. H. Smith, two lectures on Illustrations of Ancient Greek and Roman Life in the British Museum; Lieutenant-Colonel E. Gold, two lectures on The Upper Air; Sir F. W. Dyson, Astronomer Royal, three lectures on The Astronomical Evidence bearing on Einstein's Theory of Gravitation; and Sir J. J. Thomson, six lectures on Positive Rays. The Friday evening discourses will begin on Friday, January 16, 1920, at 9 o'cock, when Sir James Dewar will deliver a discourse on Low-temperature Studies. Succeeding discourses will probably be given by Sir C. A. Parsons, Mr. S. G. Brown, Professor W. M. Bayliss, Dr. E. J. Russell, Mr. W. B. Hardy, the Hon. J. W. Fortescue, Professor J. A. Fleming, Mr. E. McCurdy, Sir J. J. Thomson, and others.

SCIENTIFIC NOTES AND NEWS

At a meeting of the Société de Pathologie exotique at the Institut Pasteur of Paris, held on December 10, Dr Simon Flexner of The Rockefeller Institute for Medical Research, in New York, was elected an associate member. Dr. Flexner was also elected to associate membership in the Société Royale des Sciences Médicales et Naturelles of Brussels, at a meeting held on December 1, and to the Société Belge de Biologie of Brussels, at its meeting of December 6. On December 22, Dr. Flexner was made a corresponding member of the Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte of Rotterdam, Holland.

Official notice has been issued by the French Academy of Sciences of the award of

the Bordin prize in mathematics to Dr. S. Lefschetz, assistant professor of mathematics in the University of Kansas, and of the Lalande prize in astronomy to Dr. V. M. Slipher, director of the Lowell Observatory at Flagstaff.

FORMER assistants of Dr. Edwin R. Le Count, professor of pathology in Rush Medical College, tendered him a banquet on December 17 and presented him with two paintings as a recognition of esteem and gratitude. The presentation address was made by Dr. Frank R. Nuzum, Janesville, Wis., who presided. Addresses were also made by Drs. Herman A. Brennecke, Aurora; George E. Clements, Crawfordsville, Ind.; William H. Burmeister, George H. Coleman, Arthur H. Curtis, Morris Fishbein, Edward H. Hatton and James P. Simonds, Chicago.

SURGEON GENERAL SIR ALFRED KEOGH and Sir Almroth E. Wright have had the honorary degree of doctor of science conferred on them by the University of Leeds.

SIR DONALD MACALLISTER, superintendent of the British Medical Council, has been invested by President Poincaré, with the cross of the commander of the Legion of Honor.

DR. A. S. LOEVENHART, professor of pharmacology and toxicology at the University of Wisconsin, was elected president of the Pharmacological Society at the annual meeting held in Cleveland last week.

MR. ELMER H. FINCH, geologist of the U. S. Geological Survey, has recently been appointed chairman of the Mineral Division Land Classification Branch, U. S. Geological Survey, succeeding Mr. A. R. Schultz, resigned.

DR. FOREST B. H. BROWN, research fellow at Yale University, has been appointed botanist on the staff of the Bishop Museum at Honolulu. Dr. Elizabeth Wuist Brown has been appointed research associate in cryptogamic botany in the same institution.

DR. P. G. AGNEW, physicist in the Electrical Division of the Bureau of Standards, has resigned to become secretary of the American Engineering Standards Committee, with headquarters at the Engineering Building, 29 West 39th Street, New York City.

DR. ARTHUR LACHMAN, a well-known chemist of San Francisco, formerly professor in the University of Oregon, was last seen on the street at noon on December 11, 1919. Since then his family and friends have been unable to obtain any clue or any trace of his whereabouts. It seems probable that he had an attack of amnesia with loss of identity and wandered away. Dr. Lachman is known to many readers of SCIENCE. Any one having information in regard to him is requested to communicate with his family or with Dr. Felix Langfeld, 272 Post St., San Francisco, California.

LANCASTER D. BURLING, invertebrate paleontologist of the Geological Survey of Canada, has accepted the position of geologist with S. Pearsons and Sons, Limited, of London, England. His first assignment is to work in the old fields of Trinidad, for which he will leave upon the first available sailing.

CAPTAIN W. E. BROPHY, C.E. (Columbia, '15), formerly of the Barrett Company and later of the Chemical Warfare Service, U. S. A., has joined the engineering staff of Arthur D. Little, Inc., at Cambridge, Mass. In the early part of the war, Captain Brophy had charge of the construction and operation of the plant at Astoria, Long Island, for the manufacture of high absorbent carbon for use in gas masks and later he designed, constructed and operated an additional unit for the purpose at San Francisco.

DR. HIDEYO NOGUCHI, of the Rockefeller Institute for Medical Research, has landed at the port of Progreso from which he will proceed to Merida in order to carry on confirmatory studies of his discovery of *L. icteroides* and to try on a larger scale the curative properties of the specific serum prepared by him.

MR. N. H. DARTON, geologist of the U. S. Geological Survey, will spend two months in the Dominican Republic early in 1920 to investigate oil conditions for a New York company.

At the thirty-sixth Annual Convention of the Association of Official Agricultural Chemists held at Washington beginning on November 17 the following officers were appointed for the ensuing year: *President* H. C. Lythgoe, State Department of Health, Boston, Mass.; *Vice-president,* W. F. Hand, Agricultural College, Agricultural College, Miss.; *Secretary-Treasurer,* C. L. Alsberg, Bureau of Chemistry Department of Agriculture, Washington, D. C. Additional members of the Executive Committee are C. H. Jones, University of Vermont, Burlington, Vt., and W. W. Skinner, Bureau of Chemistry, Washington, D. C.

At the annual meeting of the Washington Academy of Sciences, held on January 13, Dr. F. L. Ransome, delivered the address of the retiring president on "The Functions and Ideals of a National Geological Survey."

The sixth lecture of the series of The Harvey Society will be by Dr. Carl Voegtlin, professor of pharmacology, United States Public Health Service, on "Recent Work on Pellagra" at the New York Academy of Medicine on January 24 at 830.

Dr. George Macloskie, professor emeritus of biology of Princeton University, died at Princeton, on December 4 in his eighty-fifth year.

The death is announced of Professor A. Ricco, director of the Observatory of Catania and vice-president of the International Astronomical Union.

The death is announced of Professor E. H. Bruns the director of the University Observatory at Leipzig.

UNIVERSITY AND EDUCATIONAL NEWS

An anonymous gift of $1,000,000 has been offered to Throop College of Technology, at Pasadena, California, conditional upon an equal amount being raised from other sources.

Mr. Gustavus F. Swift, of Chicago, has added $8,000 to the previous endowment of the Gustavus F. Swift Fellowship of the University of Chicago, making the income from that fellowship amount to $925. This fellowship is awarded for the encouragement of research, and is given only to a student who has already proved his capacity for investigation.

Dr. William H. Walker, head of the Research Library of Applied Chemistry at the Massachusetts Institute of Technology, has been appointed head of the new division of industrial cooperation and research.

Dr. M. G. Seelig, has accepted the position of professor of clinical surgery, at the School of Medicine of Washington University at St. Louis, Mo.

Dr. Walter H. Eddy, of Teachers College, Columbia University, associate in physiological chemistry, has been appointed assistant professor of physiological chemistry. Dr. Eddy has recently returned from France, where he served fifteen months with the A. E. F., as major in the Sanitary Corps.

Harold S. Palmer, instructor in geology in Trinity College, Hartford, Conn., leaves on February 1 for Honolulu to take charge of the department of geology in the University of Hawaii.

Sir Richard Glazebrook, who recently returned from the directorship of the British National Physical Laboratory, has been appointed to the Zaharoff chair of aviation tenable at the Imperial College of Science and Technology, founded by Sir Basil Zaharoff, who gave to the university the sum of £25,000 for this purpose.

Dr. G. M. Robertson has been appointed to a professorship of psychiatry and Dr. J. H. Ashworth to a professorship of zoology in the University of Edinburgh.

Dr. Fritz Paneth, director of the chemical department of the German technical high schools at Prague, has been appointed professor of chemistry at the University of Hamburg.

DISCUSSION AND CORRESPONDENCE

MUSICAL SANDS

The article on "Singing sands of Lake Michigan" by W. D. Richardson, in Science,

November 28, gives suggestion for the present writing.

The phenomenon of sonorous sands was very thoroughly studied in the years 1882–1889 by Dr. H. Carrington Bolton and Dr. Alexis A. Julien, both of New York City. The very interesting results of their enthusiastic research were published in several short articles in the *Proceedings* of the American Association for the Advancement of Science and in the *Transactions* of the New York Academy of Sciences. A brief review of their work may be worth the space.

The preliminary paper was read at the Minneapolis meeting of the Association, 1883, describing their study of the musical sands at Manchester, Mass., and on the island of Eigg in the Hebrides; with reference to many other localities. This paper is printed in the *Proceedings,* volume 32, pages 251–252.

After a year of extensive travel and study of the phenomenon, and with voluminous correspondence, a second paper was read at the Philadelphia meeting, 1884, and printed in abstract in volume 33 of the *Proceedings,* pages 408–415. In this article the sounds emitted by the sands are indicated by musical notation. Some search of old writings had shown that allusions to the phenomenon were found in the literature of the past one thousand years; and that famous localities, like Jebel Nagous, had been visited by many travelers. A brief chronology of the study and writings from the sixteenth century was included.

In Volume 3 of the New York Academy *Transactions,* pages 72–76 and 97–99, for 1884, Dr. Bolton described the phenomenon on the Baltic coast, and in the sand-hill of Arabia and Afghanistan, especially at Jabel Nakous, or "Mountain of the Bell" on the Gulf of Suez. A paragraph at the close of that article is worth quoting.

> The localities in which sonorous sand is found may be divided into three classes: first, sea- and fresh-water beaches, where all the sand possesses the sound-producing quality permanently, as at Eigg, Manchester, Plattsburg, etc.; secondly, sea-beaches where small tracts of the sand possess acoustic properties transiently, as along the Atlantic coast, in New Jersey, North Carolina, and on the Baltic; thirdly, sand-hills in the interior or otherwise, whose steep slopes give rise to acoustic phenomena of great magnitude, as at Kauai, in Nevada, and at Jebel Nakous and Reg Ruwan.

Volume 8 of the Academy *Transactions,* 1888, pages 9–10, prints a letter giving the conclusion of the authors as to the cause of the sounds. And on pages 181–184 is given a very interesting letter of Dr. Bolton, from Egypt, describing his visit to Jabel Nagous. In Volume 9, 1889–1890, pages 21–25, Dr. Bolton gives a fuller account of his visit to Arabia Petraea, and also a summary of the conclusions reached by Dr. Julien and himself, as follows:

> Dr. Julien and I believe that the true cause of sonorousness in the sands of singing beaches and of deserts is connected with thin pellicles or films of air, or of gases thence derived, deposited and condensed upon the surface of the sand-grains during gradual evaporation after wetting by seas and lakes or by rains. By virtue of these films, the sand-grains become separated by elastic cushions of condensed gases, capable of considerable vibration, and whose thickness we have approximately determined. The extent of the vibration and the volume and pitch of the sound thereby produced, after any quick disturbance of the sand, we also find to be largely dependent upon the forms, structures and surfaces of the sand-grains, and especially upon their purity or freedom from fine silt or dust.

In Volume 8, page 10, of the New York Academy *Transactions,* is described the opening by Dr. Bolton of two packages of sea sand collected at Rockaway Beach four and five years previous, and which gave distinct high notes when quickly rubbed or shaken.

The present writer has a large bottle of the Rockaway Beach sand, collected with Dr. Bolton on that summer day in 1884, when the beach was singing clearly. The bottle has been closed with a cork stopper, but was opened, for a minute, a few years ago for removing a sample. The bulk of the sand has been in the bottle over thirty-five years. This day, December 2, it has been poured into a stocking, and when quickly compressed has

given clearly the characteristic high note, audible at considerable distance. But since it has been spread out in the warm dry room, and received some handling, it has lost the sonorous quality.

H. L. Fairchild

University of Rochester

MORE ON SINGING SANDS

To the Editor of Science: The comment of Mr. Richardson in a recent number of Science (November 28, 1919) on the singing sands of Lake Michigan, calls to mind some observations made a number of years ago that should be considered in connection with the hypothesis he advances to explain the singing quality of the sand.

These sands were encountered by us in connection with the soil survey of Allegan, county, Michigan. The singing quality was particularly well developed within four to six rods of the lake shore. We collected a sample of several hundred pounds which was forwarded to the Bureau of Soils at Washington. After the material was in the sack on the beach, the singing quality could be developed by merely running the fingers through the sands.

The material was shipped by freight and stored in the basement of the building then occupied by the bureau. Some months later the material was looked up and examined. It had completely lost its singing quality. Of course it had dried out. There was no leaching and presumably no change in chemical composition.

It has seemed to me that this quality is associated with two primary factors namely: (*a*) Very well rounded and smooth particles, (*b*) A particular amount and condition of moisture. Neither a very wet nor a very dry condition suffices. We have noticed a slight tendency to this singing quality in walking over the sand dunes in that section of Michigan, if the foot is jammed into the sand so as to get below the very dry surface layer and into contact with the somewhat moist sand immediately below.

I am inclined to think the percentage of moisture when coupled with the smooth, rounded particles is the chief factor in developing singing sand. That per cent. is somewhere in the region of the lento-capillary point or the margin between hygroscopic and free capillary moisture where, due to surface attraction of the sand particle, film movement is very sluggish. It might be defined as the first stage of film solidification.

Elmer O. Fippin

THE INITIAL COURSE IN BIOLOGY

The botanists are more and more loudly proclaiming their academic rights as against the zoologists. In most American universities now there is a course in general biology, and it is given, often entirely, by the department of zoology. It is a very large course, running sometimes to several hundred students a year. It involves a large staff, assistant professors, instructors and assistants, and thus provides places for graduate students without fellowships. Sometimes it carries more patronage than all the other courses in zoology, botany and related subjects combined.

Naturally the botanists feel aggrieved, when they compare the few students who reach their courses, and the inadequacy of the assistantships for their support in botany, with the opulent conditions in the department of zoology.

Professor George E. Nichols has presented recently in Science data bearing on this matter, and has discussed with fairness and ability the question of the initial course in biology. The initial course in any field is a difficult subject: whether it should be designed primarily as introductory for those who intend to go further, or as broadly educational for those who can not.

I take it as axiomatic that there is a certain minimum of information regarding matters biological which every educated man ought to have, and that this would consist particularly in some knowledge of the living human body. In fact, however, a large number of students are passing through our universities, many are even taking courses in biology, who fail

to obtain this minimum. I have known of engineering students who believed that the child is born through the umbilicus. I have sat opposite to an astronomer who refused to finish a glass of dark beer when he learned that in passing from his mouth and stomach to his kidneys the black and foaming fluid in the glass in front of him would have to go through his heart.

I am inclined to agree with Professor Nichols that general biology, as given by zoologists, is a course which is suited primarily to introduce students to animal morphology. But I doubt whether a course of this sort half as long, followed in February by an exactly similar course by botanists and introducing students equally to plant morphology, would be a better arrangement.

To my mind neither the zoologists nor the botanists should give the initial course, for if either or both have a hand in it, it will have the emphasis of a specialist. It will deal primarily with morphology plus a single function, that of reproduction.

The initial course should be a course in physiology. I may illustrate what I mean by speaking of zoologists as specialists, by quoting a distinction which I once heard a physicist give of the difference, as he saw it impartially, between zoology, or general biology, on the one hand, and physiology on the other. The former, he said, dealt with reproduction, the latter with all the other functions of life.

Now it is nice to know about amebæ and frogs and the germination of seeds, but a lawyer, or an engineer, or a journalist, or even a doctor, can get along and yet know very little of such matters. If, however, he has no notion of his own insides—of what purpose his food serves, and of why he keeps breathing—well, he simply is not an educated man.

Even for the student who is going far in zoology, or botany, I believe that the first great lesson should be in function, with structure included along with, but not emphasized above, chemical and physical basic facts.

The student should begin, therefore, in that field in which knowledge of function has been most highly developed, a field which has the most powerful appeal for a human being, the field of "human," that is, mammalian, physiology as presented par excellence in that marvelous little book, Huxley's "Lessons in Elementary Physiology."

It seems—at least some of us hope—that today we are about to see a displacement of the academic college course in favor of a junior college, which would give such general subjects as the languages, American history, elementary chemistry and physics, and the one or two other things that every one should have; to be followed in the senior college by groups of increasingly specialized studies, each group aimed to a definite end. If this is to come, neither the course in general biology which Professor Nichols condemns, nor the combined elementary zoology-botany which he favors, is entitled to a place in the curriculum of the junior college.

But a brief course in human physiology is. At least, so thinks a physiologist.

YANDELL HENDERSON

YALE UNIVERSITY

SCIENTIFIC BOOKS

The Fauna of the Clyde Sea Area, being an attempt to record the zoological results obtained by the late Sir John Murray and his assistants on board S. Y. *Medusa* during the years 1884 to 1892. By JAMES CHUMLEY. Glasgow. Printed at the University Press. 1918. Pages vi + 200, 1 map and 3 figures in text.

The former secretary of the Challenger Office and of the Lake Survey of Scotland, Mr. James Chumley, for many years associated with the late oceanographer and marine zoologist, Sir John Murray, has compiled the data regarding the latter's explorations of the Clyde Sea Area in a "Fauna" of that region. The work has been financed by the Carnegie trustees for the universities of Scotland. The work contains brief account of the Scottish biological stations at Granton and Millport, which respectively preceded and succeeded the explorations which are here summarized.

The physiographic investigations made during this survey were published in the Transactions of the Royal Society of Edinburgh in 1892 and 1894 by Dr. H. R. Mill, but the zoological results had never been assembled for publication.

The region surveyed has an area of 1,160 square miles and includes the Arran Basin, the Great Plateau at its mouth, the Estuary of the Clyde, and a series of narrow locks or fiords of which Loch Tyne is the largest. These locks have about 95 per cent. of normal sea water and receive a mean tidal increment of about 4 per cent. of their total volume so that the habitat is typically marine in most essential particulars, but modified by restrictions on circulation and the resulting conditions in temperature typical of fiords.

The seven typical regions are treated separately in the faunistic summaries in which the species are arranged systematically from Protozoa to Vertebrata, with notes on localities, depths and frequencies. All groups are represented except parasitic ones and Protozoa other than Foraminifera, but somewhat unevenly and in the older nomenclatures in some instances. The records are based mainly upon the catches of the dredge rather than those of the plankton net. There are two full bibliographies arranged chronologically and systematically. A grand summary includes 806 species of which only 8 per cent. are found in all of the seven subdivisions. It is highly probable that further explorations will greatly increase the elements of the fauna common to the several subdivisions.

This faunistic study will be useful to American investigators of the North Atlantic fauna as well as to those who will frequent the newly established Bute Marine Laboratory at Rothesay in the Clyde Sea Area, which for research purposes replaces the Scottish Marine Laboratory at Millport, Isle of Cumbrae, which is now in the possession of amateur interests and in the service of more popular aspects of the biological sciences. It is to be hoped that the unparalleled service to marine zoology rendered by Sir John Murray may in time be recognized by a memorial on the shores of Scotland in the form of a marine biological and oceanographical research station whose equipment and work will be worthy of the name it should bear.

Charles A. Kofoid
University of California

THE ECOLOGICAL SOCIETY AND ITS OPPORTUNITY

Perhaps no other scientific body in this country has the opportunities for cooperation possessed by the Ecological Society. Its membership is made up of workers in zoology, botany and forestry; its field is no less than the relation of all life to its environment. Last summer five members of the Ecological Society, representing zoology, botany and forestry, camped together near the summit of Mt. Marcy in the Adirondack mountains of New York for the purpose of doing a concrete piece of cooperative research on the plants and animals at timber line, and to bring together into a list some of the problems in ecology. The persons and institutions cooperating were: Barrington Moore, president of the Ecological Society, Norman Taylor, for the Brooklyn Botanic Garden, George P. Burns for the Vermont Agricultural Experiment Station, Charles C. Adams and T. L. Hankinson for the New York State College of Forestry at Syracuse.

The results of the study at timber-line will be published elsewhere. The list of problems is given below. The list is by no means all inclusive, nor does it attempt to be thoroughly logical. It states general problems, with their subdivisions, and gives also a number of specific problems which in reality form parts of general problems. The purpose of this list is threefold: (1) to show gaps in our scientific knowledge, or subjects in which the fundamental facts needed for further human progress are lacking; (2) to show subjects in which cooperation is essential, subjects which a given science can carry only to a certain point and which must be taken up by one or more other sciences for solution; (3) to suggest specific problems for research workers and students.

GENERAL PROBLEMS

I. Factors influencing the distribution of land plants and animals.
  (1) Geographic position.
  (2) Altitude. How far does altitude per se influence distribution?
  (3) Topography.
    (*a*) Aspect, steepness of slope, valleys, benches and other land forms.
    (*b*) Influence of size of land mass of mountains, *i. e.*, isolated mountains *vs.* mountain masses.
    (*c*) Influence of water masses.
  (4) Historical factors.
    (*a*) Physical (geology, past climate).
    (*b*) Biotic.
  (5) Climate.
    (*a*) Moisture.
    (*b*) Temperature.
    (*c*) Solar radiation or insolation.
    (*d*) Light.
    (*e*) Wind.
  (6) Soil.
    (*a*) Physical properties.
      1. Texture, desirability of a physical constant: is wilting coefficient such a constant?
      2. Soil moisture.
      3. Soil air.
      4. Soil temperature.
      5. Soil stratification or profile.
    (*b*) Chemical properties.
      1. Solutions.
        (*a*) Aqueous extracts (correlations with fertility.
        (*b*) Acid extracts.
        (*c*) Full analyses.
      2. Gases. Chemical properties of soil air.
    (*c*) Biotic properties. All life plant as well as animal, influencing the soil.

II. Factors influencing the distribution of aquatic plants and animals.
  A. Standing water.
    (1) Geographic position.
    (2) Altitude.
    (3) Depth, and fluctuations of depth.
    (4) Historical factors.
      (*a*) Physical (geology, past climate).
      (*b*) Biotic.
    (5) Climate.
      (*a*) Temperature.
      (*b*) Solar radiation or insolation.
      (*c*) Light.
      (*d*) Wind. Important in aeration of water.
    (6) Water solution.
      (*a*) Color and turbidity.
      (*b*) Mineral and organic content.
      (*c*) Gaseous content.
    (7) Biotic factors.
    (8) Bottom.
  B. Running water.
    (1) Geographic position.
    (2) Altitude.
    (3) Fluctuation.
      (*a*) Whether it fluctuates at all (streams on east slope of Cascade Mts. of Oregon do not fluctuate).
      (*b*) Extent of fluctuation.
      (*c*) Period of fluctuation (diurnal or irregular).
    (4) Swiftness.
    (5) Depth.
    (6) Historical factors.
    (7) Climate.
      (*a*) Temperature.
      (*b*) Solar radiation or insolation.
      (*c*) Light.
      (*d*) Wind.
    (8) Water solution.
      (*a*) Color and turbidity.
      (*b*) Mineral and organic content.
    (9) Biotic factors.
    (10) Bottom.

III. Studies of factors influencing distribution. (A suggested method of procedure).
  A. Field survey of the problem.
    (1) To determine significant associations of plants and animals.
    (2) Determination of center and extremes (northern and southern, or east and west, or upper and lower in altitude).
    (3) Instrumental readings at each of the above points, and their interpretation.
  B. Laboratory studies.
    (1) Growth under controlled conditions (with recording instruments if possible).
    (2) Analysis of critical effects.

(3) Determination of specific requirements.

C. Field interpretation of laboratory results. (In the case of temperature this will probably mean remeasurements unless recording instruments have been used.)

IV. Studies of plants and animals at the edges of their ranges. Determination of the environment at the edge of the ranges of plants and animals should help to give, for the different environmental factors, the limits within which individual species of plants and animals can grow.

V. Ecological differentiation in plants and animals, structural and functional.

(*a*) Ecological differentiation in single species.

(*b*) Growth forms and regional distribution. Frequency of occurrence and abundance, correlated with environmental factors.

VI. Migration of plant and animals.

(1) Wind.
(2) Animals.
(3) Water.
(4) Free movement of organisms.
(5) Landslides and avalanches.
(6) Movement of environment.

VII. Relation of present plant and animal life to past floras and faunas.

(1) In unglaciated regions.
(2) In glaciated regions.
(3) Post-glacial changes.

VIII. Origin and composition of organic soils. Includes forest soils, humus, peat, muck, etc.

IX. Studies of soil organisms. Bacteria, nematodes, fungi and other organisms.

SPECIAL PROBLEMS

X. Relation of osmotic pressure to elongation.

XI. Relation of temperature to root absorption.

XII. Seasonal rhythm in organism, *e. g.:*

(1) Resting period.
(2) Photosynthesis of evergreens in winter.

XIII. Relation of mycorrhiza to root hair development. (Part of general problem of symbiosis.)

XIV. Composition of light under forest canopies. Is this diffused light or light of different composition?

XV. Effect of shade on chlorophyll content.

XVI. Water requirement of forest trees.

XVII. Nutrition of forest trees. Influence of various kinds of soils.

XVIII. Minimum requirement of solar energy for tree seedling growth or leaf development.

XIX. Factors controlling the natural pruning of forest trees.

XX. Factors controlling the non-periodic shedding of the leaves of forest trees.

XXI. Study of seed bed in forests under natural conditions, in relation to germination and establishment; comparison of seed bed in forests with nursery seed beds.

XXII. Sensitiveness of roots of different species to: (*a*) lack of oxygen, (*b*) soil acidity, and (*c*) soil alkalinity.

XXIII. Studies of fungi in forest soils.

(1) With relation to rendering nutrients (chiefly nitrogen) available to plants.
(2) With relation to soil reaction (acidity or alkalinity).
(3) Influence on ventilation.
(4) Effect on plant roots.

XXIV. Selective absorption of roots in soil.

(1) Under different soil moisture conditions.
(2) Under different atmospheric conditions.

XXV. Pull exerted by roots in withdrawing water from soils under different moisture conditions. Influence of atmospheric conditions

Barrington Moore,
Chairman Committee on Cooperation

THE CANADIAN BRANCH OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY

The first annual meeting of the Canadian Branch of the American Phytopathological Society was held at the Ontario Agricultural College, Guelph, Ontario, December 11 and 12.

Canadian phytopathologists were well represented at this meeting. Among those taking active part in the proceedings were: Dr. A. H. R. Buller, University of Manitoba; Dr. J. H. Faull, Toronto University; Mr. P. A. Murphy, Dominion Laboratory of Plant Pathology, Charlottetown, P. E. I.; Mr. W. H. Rankin, St. Catharines; Mr. W. P. Fraser, Saskatoon, Sask.; R. J. Blair, Forest Products Laboratories, Montreal; Mr. F. L. Drayton, Central Experimental Farm, Ottawa; Professor L. Cæsar, Professor J. E. Howitt and Dr. R. E. Stone, Ontario Agricultural College.

The president, Professor J. E. Howitt, in his address dealt with what should be the aims of this society. These, briefly summarized, are as follows:

First. To provide adequate facilities for the training of research men in plant pathology in Canada.

Second. To make provision for the publication in Canada of the results of scientific investigations in plant pathology not of interest to the general public.

Third. To make available to the general public the practical application of results obtained from scientific research in plant pathology.

Fourth. The unification of recommendations made by the various pathologists regarding the control of the more common diseases.

Fifth. The carrying out of a plant disease survey to secure information concerning the financial losses caused by disease to agriculture and forestry and the distribution of plant diseases throughout Canada.

Sixth. The adoption of a standard of qualifications required of men entering the field of plant pathology in Canada.

Seventh. The apppointment of an advisory board to confer with the federal and provincial authorities regarding plant quarantine and other restrictive legislation.

Eighth. The maintaining of a bibliography of Canadian plant pathology.

Dr. E. C. Stakman, of the University of Minnesota, was a guest of the Canadian Branch and dealt with the cereal rust problems in the United States and Canada.

The papers on the following program were given at this meeting:

President's address, J. E. Howitt.

"Health and disease in plants," F. L. Drayton.

"Decay in timber of pulp and paper mill roofs." (Illustrated with lantern slides.) R. J. Blair.

"Butt rots of the balsam fir in Quebec Province," W. H. Rankin.

"Leaf blight of the white pine," J. H. Faull.

"Pseudorhiza of certain saprophytic and parasitic agaricinae" (illustrated), A. H. R. Buller.

Address of Welcome, President G. C. Creelman.

Address, Dr. E. C. Stakman.

"Education of plant pathologists." Discussion led by Dr. J. H. Faull.

"Witches broom of the Canada Balsam and the alternate hosts of the causal organism," R. E. Stone.

"Some comparative observations upon the shape of *Basidia* and method of spore discharge in the Uredineæ and Hymenomycetes," A. H. R. Buller. (Illustrated with models and lantern slides.)

"Smut of western rye grass," W. P. Fraser.

Address, E. C. Stakman.

"Some observations made in inspecting for leaf roll and mosaic of potatoes," J. E. Howitt.

"New or little-known diseases of potatoes which cause the running out of seed," P. A. Murphy.

"Breeding beans for disease resistance," G. P. McRoster.

"Combination sprays for apple and potato," G. E. Sanders. (By title.)

"Some data on peach yellows and little peach," L. Cæsar.

"Fungi new to Ontario," A. W. McCallum.

"Some fungi and plant diseases comparatively new to Ontario," R. E. Stone and J. E. Howitt.

The following officers were elected for 1920:

President—Dr. A. H. R. Buller.

Vice-president—Dr. J. H. Faull.

Secretary-Treasurer—Dr. R. E. Stone.

Additional Members of the Council—Professor J. E. Howitt and Mr. F. L. Drayton.

THE AMERICAN CHEMICAL SOCIETY. VI

Colloidal reactions fundamental to growth: D. T. MACDOUGAL. (By title.) Living cell masses from the growing parts of plants in which the H-ion of the sap varies from PH, 3.9 to 7 may show an unsatisfied hydration (absorption) capacity which causes a swelling of 6 to 80 per cent. in thickness in distilled water at 18 to 20 C. Dried (dead) sections of the same material in which the salts originally dissolved in the sap have been adsorbed by solids at high concentrations during the progress of desiccation, show (total absorption) hydration capacities which causes enlargements as high as 550 per cent. of the volume of the dried material. The aspect of comparative swellings in acid and basic solutions (tested between 0.5 M and 0.000001 M) in the two cases are different, probably due to changes in the colloids caused by the adsorption of salts, etc. The actual volume reached by such material in swelling includes some osmotic action and is limited by the morphological or mechanical features of the tissues. Artificial mixtures of pentosans, agar, mucilage and gum, and of plant albumins made up to simulate so far as possible the composition of the plasmatic (living) colloids, show comparative hydrations or total swelling similar to cell masses, and of an equiva-

lent or greater amplitude. Specially prepared and purified agar and albumins prepared by E. R. Squibb & Sons are used in these experiments. Some of the results obtained are not explainable on the basis of the simple action of the H or OH ions, especially in the use of alkaline hydroxides, ammonia and amino-compounds. The reactions noted are fundamental or contributory to growth.

The antiscorbutic value of the banana: H. B. Lewis. (By title.)

A study of various culture media, especially with reference to increasing their buffer effects and adjusting their P_H values: M. R. Meacham, J. J. Hopfield and S. F. Acree. (By title.) Titration or buffer curves of corn meal extract, malt extract and bean extract, culture media and chestnut bark extract, are shown. The desirability of adding acids, bases and salts to these extracts to make them more useful as culture media by increasing their buffer effect is pointed out. The further object of rendering, at the same time, the titration curves as near straight lines as possible is sought. Data and curves are given showing the practical attainment of these objects for two of the media. The preparation of the media is carefully described, so as to make possible their reproduction to within 0.25 to 0.50 of a P_H unit.

The cause of and remedy for certain inaccuracies in Hausmann's nitrogen distribution method: S. L. Jodidi and S. C. Moulton. (By title.) The proportion of acid amide nitrogen obtained by Hausmann's method, as modified by Osborne and Harris, is constant and does not depend upon the quantity of magnesium oxide applied to the distillation. The percentage of nitrogen contained in the magnesium oxide precipitate is the higher, the greater was the quantity of magnesium oxide employed in distillation, and vice versa. Conversely, the proportion of monoamino and diamino nitrogen is the smaller, the larger the amount of magnesium oxide used in distillation. In order to obtain uniform results and a minimum of "humin" nitrogen it is necessary to use the least possible amount of magnesia which is sufficient to render the substance to be distilled alkaline. In the case of plant and animal materials the uniform application of *one gram* of magnesium oxide seems to be satisfactory, while in the case of proteins *one half of one gram* suffices.

The antiscorbutic properties of raw lean beef: R. Adams Dutcher, Edith M. Pierson and Alice Biester. Guinea pigs weighing 250 to 300 grams were divided into experimental groups containing four pigs to the group. Cold water extracts of raw beef (representing 5, 10, 15 and 20 grams of beef) were fed daily to the individuals in each respective experimental unit. Other pigs received oats impregnated with chopped raw beef, the consumption of beef averaging 3 to 5 grams daily. In all cases scurvy developed in the same length of time as when the meat and meat extract were omitted from the diet, indicating that raw beef does not possess antiscorbutic properties so far as these properties can be ascertained by the method described.

Preliminary observations on the influence of the diet of the cow on the antiscorbutic and growth promoting properties of milk: R. Adams Dutcher, Edith M. Pierson and Alice Biester. Guinea pigs receiving a daily diet of oats (ad lib.), water, and 25 c.c. of autoclaved milk (from stall-fed cows) developed scurvy in 15 to 18 days and died in 25 to 30 days with great loss in body weight. When 20 c.c. of autoclaved milk (from cows fed on grain and green grass) were substituted for the "stall fed" milk, scurvy developed 10 to 15 days later and death did not ensue for 40 to 60 days and no great loss in body weight occurred. Raw, pasteurized and separated milk (from cows on green grass) has been fed, and the results indicate that the nutritive value of these milks is higher than milk from other sources.

Rhubarb as an antiscorbutic: Edith M. Pierson and R. Adams Dutcher. Guinea pigs which have developed scurvy may be relieved and cured by introducing into the diet solid rhubarb, raw rhubarb juice, or rhubarb juice which has been boiled for fifteen minutes.

The function of vitamin in the metabolism of Sclerotinia cinerea: J. J. Willaman. (By title.) The brown-rot fungus will not grow normally on purely synthetic media. When these media are supplemented by additions of vitamin, normal growth occurs. The vitamin has been prepared by adsorption on fuller's earth from a large variety of materials, including peach and plumb juices, young tomato leaves, sprouts of beans, wheat and potato, the leaf buds of beans, fungus mycelia and sporophores, yeast, corn pollen, milk and pancreatin. Every material examined yielded the vitamin. Those materials which are characterized by high respiratory activity, either actual or potential, such as yeast, pollen, fungus spores, gave the most active vitamin preparations, both for vegetative growth and for reproduction. It is be-

lieved from these results that the vitamin in question will be found universally distributed in plant and animal tissues, and that it plays an essential part in the respiratory process. The evidence favors the view that this vitamin is the water-soluble antineuritic B.

The preparation of a stable vitamine product and its value in nutrition: H. E. DUBIN. An active stable vitamine product has been prepared from corn, autolyzed yeast, and orange juice. This vitamine product, containing the antineuritic, antiscorbutic and antirachitic vitamines, has been given the name "Vitaphos." A tentative analysis shows 10 per cent. calcium oxide, 15 per cent. phosphorus (mostly organic), 3 per cent. nitrogen, and 2 per cent. fat. Experiments with pigeons, guinea pigs and finally with children receiving "Vitaphos" in the diet, gave results showing that the product possessed marked growth promoting properties and both preventive and curative properties as regards polyneuritis and scurvy. Cases of rickets treated with "Vitaphos" showed marked improvements and considerable gain in weight. Further experimentation is under way.

Chemical isolation of vitamines: C. N. MYERS AND CARL VOEGTLIN. Brief historical discussion of previous chemical work with special reference to the pioneer researches of Casimir Funk. Vitamines are classified as antineuritic, antirachitic and antiscorbutic. Autolyzed yeast filtrate was used in part of the experiments but was found unsatisfactory on account of its complexity. Mastic emulsion, Lloyd's reagent, and ferric chloride were used in removing the active material from the filtrate. These purified fractions were tested for activity on polyneuritic birds. Dried yeast was finally used as the source of active material. Purification by means of heavy metal precipitation was carried out yielding a crystalline substance.

The vitamine content of wheat flour: C. O. JOHNS, A. J. FINKS AND M. S. PAUL.

The relation of plant carotinoids to growth, fecundity and reproduction in fowls: LEROY S. PALMER AND HARRY L. KEMPSTER. White Leghorn chicks were raised from hatching to maturity on rations containing the merest traces, if not entirely devoid, of carotinoids. The full grown hens exhibited normal fecundity although the yolks of the eggs were devoid of carotinoids. The carotinoid-free eggs showed normal fertility. A second generation of chicks, free from carotinoids at hatching have been hatched from the carotinoid-free eggs. Carotinoid-free egg yolks contain a residual yellow pigment readily extracted by acetone, which is not related to the normal axanthophyll of the yolk. This paper appeared in full in the September issue of the *Journal of Biological Chemistry.*

The physiological relation between fecundity and the natural yellow pigmentation of certain breeds of fowls: LEROY S. PALMER AND HARRY L. KEMPSTER. (By title.) The fading of the yellow color from the ear lobes, beak, shanks, etc., of a hen during fecundity is due to the fact that fecundity deflects the normal path of excretion of xanthophyll from these parts of the skin to the egg yolk, with the resulting gradual disappearance of pigment from the epidermis because of natural physiological changes in the structure of the skin. It is impossible to restore xanthophyll to the epidermis or to color the adipose tissue of hens as long as fecundity exists. The loss of pigment from the ear lobes, beak, shanks, etc., as the result of egg laying, is an index of *continuous fecundity* only, not of *heavy egg laying.* This paper appeared in full in the September issue of the *Journal of Biological Chemistry.*

The influence of specific feeds and certain pigments on the color of the egg yolk and body fat of fowls: LEROY S. PALMER AND HARRY L. KEMPSTER. (By title.) Carotin and annatto are without influence on the color of the visible skin parts and adipose tissue of poultry. Sudan III. colors only the adipose tissue of non-laying hens and is without effect on the visible skin parts. With laying hens the egg yolk is colored in addition to the adipose tissue. Xanthophyll readily colors both the adipose tissue and visible skin parts of fowls of the type of the White Leghorn breed, as long as fecundity does not exist. Yellow corn and green feed are rich in xanthophyll. Hemp seed, barley, gluten feed and red corn contain traces of xanthophyll, while wheat, wheat bran, oats, cottonseed meal, meat scrap and blood meal contain negligible quantities of the pigment. This paper appeared in full in the September issue of the *Journal of Biological Chemistry.*

The relation of the natural enzymes of butter to the production of "tallowiness" through the agency of copper salts: LEROY S. PALMER AND W. B. COMBS. (By title.) "Tallowy" butter was produced by the addition of 0.017 per cent. copper lactate to both raw cream and cream which had been pasteurized at 79°–80° C. In each of several experiments typical tallowiness and bleaching oc-

curred in the raw cream butter several weeks before it appeared in the butter from the pasteurized cream. The oxidizing enzymes in raw-cream butter apparently accelerate the catalytic activity of the metallic salts which cause the production of typical "tallowy" butter. It was found that over-neutralization of the cream failed to accelerate materially the production of tallowiness by copper lactate. This paper will appear shortly in the *Journal of Dairy Science.*

The nutritive value of commercial corn gluten: C. O. Johns, A. J. Finks and M. S. Paul.

The effect of calcium on the composition of the eggs and carcase of the laying hen: G. Davis Buckner and J. H. Martin. Authors have shown that limiting the calcium supply of laying hens to that naturally occurring in the foods fed, causes a progressive thinning of the shell yet it does not materially change the percentage composition of the egg shells or their contents. The continued laying of eggs under this condition causes a gradual depletion of calcium in the carcase of the hen. It would seem from the figures obtained that as long as the economy of the hens permitted a formation of an egg shell that the contents of the shell would remain constant, thereby permitting an average supply of calcium for the proper development of the embryo of the chick.

Protein requirement in the maintenance metabolism of man: H. C. Sherman. (By title.)

The development of Tribolium confusum Duval in certain foods: Royal N. Chapman. This study has shown that the confused flour beetle, *Tribolium confusum,* grows at about the same rate in the different grades of wheat flour and in some of the so-called wheat flour substitutes, but in certain of the low grade wheat flours and in some of the "substitutes" metamorphosis is retarded. The rate of development in first middlings wheat flour was adopted as the control. The instars were plotted on the ordinate and the time in days on the abscissa in such a way that the curve of development would be a straight line bisecting the angle. When the curves of development in other foods were superimposed upon the controls they were found to be very similar except for a prolongation of the last larval instar. Since metamorphosis takes place during the last instar, this prolongation has been taken as a measure of the nutritive effect upon metamorphosis. Certain low grade wheat flours, rye flour and rice flour prolonged the last instar while corn flour, steel cut oats and a synthetic food prolonged all instars about equally.

The influence of quinine on uric acid excretion in man: H. B. Lewis and W. L. McClure. (By title.)

The uric acid content of normal human saliva: H. B. Lewis and W. S. Griffith. (By title.)

Further studies on the chemical composition of normal and ataxic pigeon brains: Mathilde L. Koch and Oscar Riddle. A second series of analyses made on brains of pigeons affected with hereditary lack of control of the voluntary movements shows deviations from the normal brain in size and chemical composition. The brains are smaller. Eight analyses made on cerebrums and cerebellums show more pronounced changes in the cerebellums. Data for the chemical changes in the brain which accompany age have been obtained for a series of ages in the pigeon. The new and earlier evidence warrants the conclusion that chemical differentiation does not proceed as rapidly in the brain of ataxic birds as in the brains of normal birds.

A comparison of the distribution of various chemical groups in parts of the human and pigeon brain: Oscar Riddle and Mathilde L. Koch. Separate analyses made of anterior and posterior parts of the normal pigeon brain make it possible to compare these with similar parts of the human brain. It is found that the *direction of the percentage differences* in composition of the two parts of the brain is the *reverse* of that of the human in the case of every chemical fraction obtained. Also, from a chemical standpoint the cerebellum of the pigeon is an intermediate of the pigeon cerebrum and the human brain (cerebrum and cerebellum). The pigeon cerebrum is chemically least differentiated, the human cerebrum most differentiated, of the four organs compared.

Charles L. Parsons,
Secretary

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